Block Island Southeast Light
Spring Street and Mohegan Trail
at Mohegan Bluffs, Southeast Point
Block Island
Washington County
Rhode Island

HAER No. RI-27

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Historic American Engineering Record
National Park Service
Department of the Interior
Washington, DC 20013-7127

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HISTORIC AMERICAN ENGINEERING RECORD

BLOCK ISLAND SOUTHEAST LIGHTHOUSE

HAER NO. RI-27

Location: Spring Street and the Mohegan Trail at Mohegan Bluffs, at the Southeast point of Block Island, New Shoreham, Washington County, Rhode Island.

Date of Erection: Plans for the construction of the Block Island Southeast Light were approved in 1873, although evidence suggests that construction did not begin until 1874. The lighthouse was completed and first lit on February 1, 1875. A major change was made in the lens assembly in 1929.

Present Owner: U.S. Coast Guard; currently leased by the Block Island Southeast Light Foundation, Inc.

Present Use: Manned aid to navigation.

Significance: The Block Island Southeast Lighthouse is significant as a primary aid to the navigation of an otherwise dangerous area, once referred to as the "stumbling block" of the New England coast. It marks the first island landfall for ships approaching New England from the south or southeast. It was the second light to be built on the island and the first on the south side. At the time of its completion in 1875 it was considered to be one of the finest and best equipped lighthouses on the east coast, featuring a first order Fresnel lens, the best in lighting apparatus technology. The lighthouse is also of significance for its interesting design, a melding of Gothic Revival and Italianate styles taking form in an octagonal tower.

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Historic American Engineering Record
National Park Service
Summer 1988

Sailing off the coast of New England, the sun sinks slowly in the western sky, and darkness falls. Night sailing on America's northeastern coasts is relatively safe due to the great number of lighted aids to navigation under the jurisdiction of the U.S. Coast Guard. Therefore, the nocturnal sailor worries little as he scans the horizon for fixed or flashing lights that will guide him away from treacherous shoals and islands. The Block Island Southeast Light on the southeastern tip of Block Island, Rhode Island, will help to guide the sailor around that small land mass, known for centuries as the "Stumbling Block" of the New England coast. Viewing the Southeast Light in conjunction with other area lights, the night-time mariner can easily plot a course north towards Martha's Vineyard, or inland by way of Long Island Sound.

But imagine that our sailor's trip becomes more complicated as he sails along; a fog bank rolls into the area, obscuring the various lights along the northeastern seaboard and leaving our sailor open to the possibility of running aground. How can he proceed safely? Suddenly, a deep bass blast of a fog-signal is heard. Fortunately for many sailors caught in this situation, the Coast Guard provides more than just lighted beacons for surface navigation. Installed at most light stations and on buoys are sonic devices such as fog horns, sirens, and bells that will guide ships during inclement weather when the lighted beacons become invisible. Further aids to navigation, such as radio beacons, will also alert vessels to their positions in any type of weather.

All of the above-mentioned aids to navigation are present at the Block Island Southeast Light. In an age when the vast majority of lighthouses have been replaced by automated beacons, the Southeast Light still uses a late-nineteenth century first-order Fresnel lens and is cared for by Coast Guard personnel. The structure, which dates back to 1875, is representative of late nineteenth-century lighthouse architecture, as designed by the U.S. Lighthouse Board. Its accompanying light apparatus, with its Fresnel lens and all the latest updates in lighting technology, reflects the evolution of lens apparatus engineering. Thus, the Block Island Southeast Lighthouse is historical significance in a number of ways: as an example of the progress made in light technology, its role in the maritime history of the New England coast, and for its interesting architectural design.

This lighthouse is one of the last of the manned lighthouses in the United States. As of the summer of 1988 only nine lighthouses operated by the United States Coast Guard remained unautomated. The Southeast Light offered the unique opportunity to record a first order sea coast historic light structure and its associated technology, still in use today. The lens apparatus displays a now rare combination of new technology incorporated into a much older technology: a modern-day quartz-iodide electric lamp is used in conjunction with lenses, some of which date from the late 1800s. The modern lenses are made of plastic, although they are based on the same optical principles as the older lenses. The U.S. Coast Guard has, however, made plans to build an automated light tower on the site in the fall of 1988.

The first impression one gets of the lighthouse is of awe, particularly if the first encounter is at night. Approaching Block Island by ferry in the evening, curiosity is aroused by a flashing green light seen on a high point in the distance. A two-mile long road winds its way south from the ferry dock, occasionally passing in sight of the ocean. It leads to the rear of the lighthouse, where the imposing structure sits 150 feet above the waves on the Mohegan Bluffs, incorporating a tower which raises the total to a height of 212 feet above sea level. As the sky grows dark, the observer will see eight revolving beams of green light radiating from the lantern room at the top of the tower, appearing as the spokes of a giant wheel extending out to the sea.

Over the years, the Southeast Lighthouse's picturesque architectural style and setting have inspired many artists. It has also appeared on many tourist souvenirs since its completion in 1875, and is among the most photographed lighthouses in New England. But what lies behind the outward appearance of the site; what was there and how did it work? Who planned, designed and built the lighthouse, and how did the form and function of the light and other associated structures change over time?

The objective of this report is to address these questions. Part I will give some general historical background which led to the development of modern lighthouses. This discussion will also include information on the early light sources used. Next, we will arrive at the doorstep of the modern lighthouse era, when Augustin Jean Fresnel (Freh-**nel**) first experimented with his new lens system in the Cordouan Lighthouse in France. His ideas on lenses were developed further after his death, and formed the basis of lens technology that was used in both Europe and the United States. A final historical tangent will introduce the U.S. Lighthouse Establishment and trace its development in conjunction with the Southeast Light.

Turning to Block Island, Part II will first briefly acquaint the reader with the island's history. This discussion will lead to the reasons why, in view of its location and the needs of both island and mainland people, the selection of Block Island for a primary lighthouse was a logical choice. Included will be the individuals and groups involved in the site selection and survey process. The reasons for constructing the Southeast Light as a primary light will be discussed as well, taking into consideration regional connections such as other existing lights and their ranges. The evolution of the lens apparatus, which has gone through various changes between 1873 and 1988, will also be traced. The adjacent outbuildings on the site, likewise, have been changed over the years. For instance, the original frame fog signal house was completed prior to the lighthouse structure, but the remaining fog signal structure (no longer in use) is made of brick. Radio towers have come and gone; and for a brief time, a telegraph station was in operation on the site.

What were the major site changes that occurred between 1873 and 1988? The final section will point these out as a means of tying together the history of the Block Island Southeast Lighthouse, and leading into a discussion of the function and fate of this lighthouse as of 1988.

Part I - In the Beginning...

General History of Lighthouses

As did much of the history of the world, the history of lighthouses began in Egypt. The majority of port cities faced a dilemma: It was important to guide traders into the harbor area, but the cities did not want to supply navigational aids to potential invaders. As certain empires, such as Egypt, grew it became safer to establish beacons, knowing that no one would dare attack a mighty power. While other port cities used fires on hills as beacons, the city of Alexandria opted to build what we today would call the first lighthouse. What little evidence there is suggests that the Egyptians began building the tower for the light in approximately 300 B.C., on the island of Pharos[1] at the entrance to the harbor of Alexandria. It was not completed until twenty years later; archaeologists believe that the completed tower rose to a height of about 450 feet with an open fire at the top as a light source. The lighthouse was in use for the next thousand years. The tower remained standing and unlit for another five hundred years after it ceased being used as a lighthouse, until it was toppled by an earthquake.

Other empires followed suit in building lighthouses. Evidence has been found of the existence of at least thirty lighthouses in use in the Roman Empire before it began to decline in the fifth century A.D.[2] When Europe entered the Middle Ages more lighthouses were erected in Italy, Turkey, France, England, Ireland, and Germany, with the Italians foremost in the venture. Often the ports merely exhibited lights from castle towers situated near the mouth of a channel or harbor, rather than building an elaborate lighthouse. But lighthouses eventually became the norm when a government considered aids to navigation.

One of the earliest lighthouses of the new age was the French Cordouan lighthouse (which will figure prominently in later discussion on the progress of light technology), originally a very ornate structure which included a hall and chapel. Begun in 1584, it was not completed until twenty-six years later. Unfortunately, the island it was built upon gradually eroded, and in repairing the damage in 1788, Joseph Teulere removed the upper portion and replaced it with a 60 foot stone tower that still stands today.[3]

The British lighthouse historian Alan Stevenson estimates in his nineteenth century writings that the coastal lighthouses grew in number from thirty-four in 1600 to one hundred and seventy-five in 1800. During the eighteenth and nineteenth centuries, Great Britain as well as France placed a high priority on lighthouse construction in conjunction with their development as naval and mercantile powers. One of the most difficult lights to keep in operation during this era was the Eddystone light, first lighted in 1708. It required massive reconstruction by the civil engineer John Smeaton from 1756-1759, at which time he changed the lighthouse to a modified cone design. The lighthouse was made taller by Britain's Trinity House (a corporation in charge of navigational aids) in 1882. The Eddystone light is an example of the growing role played by modern engineering in the construction of lighthouses, particularly those located on unstable islands and rock piles.

Birth of the Modern Lighthouse - Reflectors, Lamps, and Lenses

According to an 1881 treatise by Thomas Stevenson, optical principles were first applied to lighthouses in 1763, when the lighthouses erected at Mersey were fitted with reflectors made of bits of looking glass affixed to the inside of a wooden bowl.[4] It was found by a Capt. Huddart of Trinity House that the curved plane of a parabolic section was the ideal for the reflectors.

Here a slight digression in the discussion will prove useful for explaining the properties of a parabolic reflector and will in turn aid one's understanding of refractive and reflective prisms. First, some definitions. All transparent materials have an <u>index of refraction</u>, which in the case of a lighthouse lens is the ratio of the velocity of light in the first of two media (ie. the air through which the light travels) to its velocity in the second (the glass of the lens). In other words, the ratio between the difference at which light travels through two elements of different densities. This is a standard ratio for properties of materials and, therefore, can be found in tables in textbooks or handbooks of physics and chemistry. For example, the ratio is 1.00 for a vacuum, 1.0002 for air, 1.333 for water, and 2.417 for a diamond.

Refraction is the change in direction of a light ray as it passes from one medium to another; the change in direction is caused by the ray's change in speed. A good example of refraction occurs when a pencil is placed in a glass of water. The portion of the pencil underwater looks bent from the portion above the water. Because the light rays in the water do not travel as fast as those in the air above it, the rays are refracted, giving rise to the appearance of a bend in the pencil.

The opposite of refraction is reflection (to throw or bend back), which happens at any surface that forms the boundary between two transparent mediums. By various laws of physics (Snell's, for instance) the index of refraction of a material indicates how much light will be reflected at a boundary. There is also a certain angle, called the critical angle, at which a light ray approaching a surface will be totally reflected rather than refracted (even for transparent materials). This is often seen when looking at a window; depending on where one stands on a sunny day, the window may appear transparent or it may act like a mirror and show a reflection. When the reflection is seen in the window, that means that those rays now reaching the eye were within the critical angle when they approached and struck the window glass.

These physical properties and laws are the essence of lighthouse lens technology. The idea of a reflector is to collect light rays which diverge from a point called the focus, and redirect the rays back in a certain direction. In silver-plated material, some of the rays will be absorbed by the plating while a majority of the rays are reflected. The law of reflection, dating from the time of Euclid, states that the angle of incidence (the angle away from a perpendicular to the reflective surface) at which a light ray strikes the surface will in turn equal the angle of reflection (the angle away from the perpendicular which the ray follows as it leaves the reflective surface). Using this property, it was first decided that the best form for a lighthouse reflector would be that of a parabola. The curved plane of a parabolic form reflects light in rays parallel to the axis of the parabola.

In about 1784, Jean Charles Borda caused to be erected in the Cordouan Tower an apparatus of truly parabolic metallic reflectors, where a lamp was placed in front of each reflector at its focus. Also, according to historical records, it was Borda's idea to revolve the lamps and reflectors, thus causing the light to flash. In a fixed light reflector system, each reflector on the frame covered approximately 14 1/2° of divergence, so twenty-five reflectors were needed to light the entire horizon (360°). In a revolving apparatus such as that suggested by Borda, a chandelier was used that had either a square or, more usually, an octagonal shape. On each flat face, a certain number of separate lamps and reflectors with parallel axes were affixed.

It was realized early in the nineteenth century that the parabolic reflector apparatus might not be the most efficient means for throwing light out to sea. A parabolic metallic reflector will reflect usefully only one-sixth of each lamp's light. The reflectors needed constant polishing due to the smoke of the lamps and this, combined with deterioration caused by exposure to marine atmospheric conditions, caused the reflectors to wear out quickly.

The solution to these problems were finally answered through the experimentation of a Frenchman, Augustin-Jean Fresnel (1788-1827), the man responsible for beginning a new era in lighthouse technology. After beginning his career as a highway engineer, Fresnel later devoted his spare time to the study of optics until, in 1821, he was appointed full-time as the Secretary to the French Commission for Lighthouses.[5] It was at this time that Fresnel began to present his views on optics and their possible application to lighthouse apparatus. He noted that convex glass lenses collected the light emitted from a light source (placed at the lens focus) and, due to the refractive or light-bending capabilities of glass, the light that was transmitted to the other side of the lens poured forth in a beam of light rays parallel to the horizontal axis of the lens. This phenomenon, known since ancient times, was crucial to Fresnel's plans for lighthouse illumination.

Fresnel proposed, essentially, that glass lenses could be substituted for parabolic reflectors in lighthouses. This substitution would greatly decrease maintenance, as glass does not deteriorate as much as metal, and it would increase the light output of the lighthouse lantern, making it easier to be seen at greater distances. To use glass lenses in lighthouses, Fresnel first had to overcome a number of problems. The use of lenses had not been considered feasible prior to Fresnel because a large lens would have been very thick; thus, the piece of glass would have a tendency to absorb more of the light than desirable, and large pieces of glass are difficult to make free of bubbles and striae that cause ray deviations. Also, any lens of the size needed for a lighthouse would be very heavy, making it difficult to install and manipulate. Nevertheless, attempts were made to these large lenses in eighteenth-century lighthouses; according to Thomas Stevenson, "Fresnel states that in 1759 lenses were actually used in some English lighthouses, but were in all probability improperly applied, for their use was afterwards abandoned."[6] The Portland, England, lighthouse is cited by Stevenson as a case where a large lens was installed but later removed.

The problem of constructing large lenses had been approached as early as 1748 by George Louis Leclerc, Comte de Buffon. He proposed that a lens of steps or concentric zones be ground out of a solid piece of glass to prevent absorption of light by the thickness of the material. The concentric zones resulted from collapsing the spherical surface of a comparably large lens. All evidence indicates that Buffon never made one of these lenses. The Marquis de Condorcet reopened the issue with his suggestion in 1773 (in his Eloge de Buffon) that Buffon's idea was correct, but that the lens should be constructed in separate sections, rather than ground down from a single large glass piece. This separate lens ring construction was also described by Sir David Brewster in the 1811 edition of the Edinburgh Encyclpaedia. A lens built from Buffon's design, where a large lens was ground into concentric rings, was first done in approximately 1780 by Abbe Rochon, but difficulties in grinding the glass caused people to lose interest.[7]

These early suggestions for step construction of lenses were directed towards the use of lenses to focus light inward to a point, rather than from a point outward in a beam, as would be the case in a lighthouse. Buffon, for instance, specifically planned to use his lens (if ever constructed) to focus the sun's rays, thereby creating a burning glass; Fresnel quotes Buffon as writing that "this echelon mirror would be one of the most useful instruments in physics."[8] Later suggestions were made to use this type of lens in chemistry as well as in physics.

Fresnel supposedly developed his lens in 1822 independent of these earlier ideas. He was the first to propose an echelon lens, in this case a lens composed of parallel concentric refracting prisms of varying sizes all having the same focus, and then follow through on its development and construction. After hearing of Buffon's theory of lens construction, Fresnel was able to point out why his was a better model (See HAER measured drawings, sheets 7 & 8). Fresnel's proposed lens almost eliminated spherical aberration, which is the divergence of light rays from a parallel beam emitted by a lens that has a spherical surface. Buffon's lens had been the surface of a simple spherical lens "caved-in" in concentric rings, neglecting the fact that each ring after this process would have a different focus. As described by Fresnel:

> We find, by calculation, that the generating arcs of the rings not only ought not to have the same center, but that their different centers should not be situated upon the axis of the lens, and that they depart from it in proportion as the arcs to which they belong are more distant from the center of the lens; so that these arcs on being revolved about the axis do not generate portions

> of concentric spherical surfaces, but surfaces of the kind known to geometricians as annular surfaces.[9]

Consequently, the individual annular lenses are not parts of concentric spheres which share a common center as in Buffon's lens. Fresnel himself states that in "the execution of lenses designed for the illumination of light-houses, it is not necessary to attain a very high degree of accuracy,"[10] but he still thought (and was correct) that the substitution of annular (ring shaped) for spherical lenses would produce a noticeable increase in the light thrown out along the axis of the lens panel. Applying his discoveries of interference, double refraction, and polarization, Fresnel calculated profiles for each lens, which were in fact prisms, in the hope of making the maximum use of the light source. Along with his decision to make annular lenses, Fresnel opted for plano-convex lens construction rather than double convex lenses, as the flat side would make it easier to grind the lens pieces, and comparatively easier to assemble on a table top.

Various men were corresponding and working with Fresnel as he attempted to create a better lighthouse lens. Dominique Francois Arago (1786-1853) contributed as a French physicist and astronomer who had done extensive work in magnetism and optics, including the invention of the polariscope and the polarimeter, and was a strong proponent of the wave theory of light. Jean Baptiste Francois Soleil, a Parisian optician, gave vital assistance to Fresnel by placing his glass grinding apparatus and invaluable skills at Fresnel's disposal.

Unfortunately for Fresenel and company, after all the planning and calculating, the first lens constructed by them in separate pieces had to have spherical surfaces rather than annular because Soleil's apparatus at that time could only construct spherical surfaces. In fact, according to Fresnel:

> That determined me to substitute, for the time being, for each annular surface an assemblage of small portions of spherical surfaces, and even to give to the rings the form of a polygon, instead of a circle, as it was more easy to work pieces of the glass in straight lines.[11]

Thus, the first lens was a polygon of straight prisms with a convex bulls-eye lens in the middle. At the suggestion of Arago, fish glue was used to connect the lens elements because it was clearer and less brittle than ordinary glue. Fresnel gives the measurements as .76 meters (approx. 2'-6") on a side, although preliminary experiments had been done with sides of .55 meters (approx. 1'-9 5/8). Each of the large lenses weighed 75 pounds, including the copper frame; therefore, the eight lens panels in the first model, with frames, weighed 600 pounds.

It became easier to manufacture a lens in circular rings when the St. Gobain glassworks of Paris sent Soleil arcs of glass cast in the glass work's molds, which he could then grind. These arcs were closer to the finished form than anything he had been able to manufacture with his own apparatus. Fresnel indicates that it was he who suggested to Soleil an apparatus for making annular surfaces on the rings instead of spherical. The glass from St. Gobain, thirty-five miles northeast of Paris, was a slightly green crown glass, whose index of refraction Fresnel calculated to be 1.51.[12] Although it was harder to make this type of glass bubble-free, and it is not as clear in color as flint glass, crown glass proved to be harder, lighter and less subject to atmospheric deterioration than flint glass, which contains some lead.

The Cordouan Lighthouse was chosen for the first installation of the new lens system using annular lenses. The rotating apparatus was comprised of eight large lenses and eight small lenses set in a bronze frame. The small lenses formed a cone above the larger lenses, collecting the upper rays of light and sending them onto large planar mirrors placed to reflect the rays to the horizon. By placing the small lenses slightly ahead of their corresponding main panels, one was able to prolong the duration of the flash. Because both mirrors and lenses were still in use, this system was known as <u>catadioptric</u>, whereas a system using only reflectors is termed <u>catoptric</u> and one using only refracting lenses is <u>dioptric</u>. As shall be discussed, later lenses that employed both refracting and reflecting prisms of glass were also referred to as catadioptric.

Fresnel had thus created a system that was geometrically perfect, but not physically perfect, as he was still using mirrors, which did not reflect efficiently all the light that reached them. Soon variations were made on the original design, first by Augustin Fresnel and then later, after his death, by his brother Leonel Fresnel. A fixed dioptric apparatus was made to add variety to lighthouse characteristics where lenses were being used. For each lens panel of this kind, the center bulls-eye lens was replaced with a refracting horizontal convex band and the annular refracting prisms centered on the bulls-eye were replaced by smaller bands above and below the middle band. The vertical angle subtended by the drum of the fixed light varied from 56° to 57°, as noted by M. Leonce Reynaud in his 1864 <u>Memoir Upon the Illumination and Beaconage of the Coasts of France</u>. These fixed lights could be made to flash by revolving several lenses of vertical elements around the dioptric drum of a fixed lens apparatus.[13] But this only served to increase the amount of material that the light had to pass through, therefore decreasing the intensity of the transmitted beam.

In the eight-panel revolving arrangement, Fresnel had noted that to avoid the great loss of rays emitted by a light source at the focus, each lens should embrace all rays included in an angle of 45°. However, he later suggested that by decreasing the angle of light embraced by some lenses, quicker flashes could be made amongst the longer ones. For instance, instead of embracing an angle of 45°, the panel would only embrace 22 1/2°. Later versions altered flashing and fixed-type panels.

At one point curved, plated mirrors were put in the upper and lower regions of the Fresnel flashing arrangement; this provided a fixed light between flashes. This idea was dropped because the mirrors required more maintenance than glass. Glass only needed its initial polish done once by machine whereas metal required constant repolishing by which it eventually became worn and scratched. Leonel Fresnel, Soleil, and Alan Stevenson all worked on the idea of using prisms in place of the upper and lower regions, prisms that first refracted and then internally reflected the light. Later experiments by Thomas Stevenson (1871) showed a 31-35% loss of light when using metal, compared to a 23% loss by total reflection in glass.[14] The improved lens and lens-"beehive" apparatus served to make approximately five-sixths of the light useful, a great improvement over the one-sixth transmission of the parabolic reflectors. It was also realized that a revolving panel apparatus would give a greater intensity of light than a fixed apparatus, because the same amount of light was being collected and concentrated through a smaller area.

Augustin Fresnel was obviously very persuasive in convincing people that his lens system was better than the parabolic reflectors. Not only did his apparatus make better use of the available light, it could be applied in different sizes depending on the need of a location; Fresnel originally designated four different orders for use in lighthouses, with the first order being the largest. The orders were first established by the number of concentric cylindrical wicks used in the lamps, a first order lens having four wicks; second, three wicks; and so forth. There were six sizes (or focal lengths) of lens; the two extra sizes resulting from substitution of a small lamp for a large one in the two smallest lens orders.

1st-order focal length =	920 mm (36.22 inches)
2nd-order focal length =	750 mm (27.55 inches)
3rd-order focal length (large lamp)=	500 mm (19.68 inches)
3rd-order focal length (small lamp)=	250 mm (9.84 inches)
4th-order focal length (large lamp)=	182.5 mm (7.38 inches)
4th-order focal length (small lamp)=	150 mm (5.90 inches)

Later, the third- and fourth-order large became the third- and fifth-orders, and the third- and fourth-order small became the fourth- and sixth-orders. A three-and-one-half order apparatus was later made with a focal length of 375 mm (14.76 inches) and in 1885 a hyper-radial lens with a focal length of 1330 mm (52.36 inches) was constructed.

All of these lenses used a single light source, another argument Fresnel used in favor of his system, pointing out that future lamp changes would be easier to make if one was concerned only with a central source rather than the numerous lamps of a parabolic reflector system. With an eye to future developments, Fresnel in 1822 noted: "In fine, all the improvements that time and experience may develop in the production of light can be with the greatest facility applied to lenticular apparatus."[15]

The development of light sources for lighthouses has gone hand-in -hand with the progress in lens technology. Light sources began simply enough, with fires built on hillsides and then candles, which led to the use of "candle power" as the unit of measure for light sources. Oil lamps were eventually used, although they required much care and cleaning. In 1677, Dr. Robert Hook noted ways to improve the burning of an oil flame, after realizing that an oil flame was actually a cone of gas, of which the outside only was on fire. But it was not until 1782 that Aime Argand acted on Hook's suggestions, "by making the wicks and burners of a hollow cylindric form, so as to admit a central current of air through the burner."[16] His lamp was thus constructed of two vertical concentric tubes with a circular wick (usually cotton) between the tubes, and a glass chimney over all. A double air current was created; the improved combustion from oxygen passing along inside and outside the wick made a cleaner light with less smoke and increased a single lamp's candlepower to approximately 7 to 10 candles.

The Argand lamp was improved by the Carcel oil burning mechanism, which provided an abundant supply of oil to the lamp. Further developments were made by Augustin Fresnel and his colleagues by increasing the number of wicks in a single lamp; the number of wicks then corresponded roughly to the different Fresnel lens-orders, with a first-order (largest) lens having the four-wick burner. The number of wicks in the largest lamp had been increased to five by the mid-nineteenth century, with the design in the United States created by George G. Meade in about 1853. Meade was at that time a young lieutenant in the army engineers assigned to lighthouse duty; later, he became a general and commanded Union forces at Gettysburg.

Colza (rapeseed oil), a product obtained from wild cabbages, was the fuel of choice in the lighthouses of Europe. As the United States did not have an indigenous strain of wild cabbage, and the farmers showed no interest in growing it, the U.S. resorted to whale oil for lamp fuel. By the mid-nineteenth century, the number of sperm whales was quickly diminishing, and America turned to lard oil. Finally, in 1878, the lamps of the United States were converted to use kerosene, or mineral oil as it was then more commonly known.

The incandescent oil vapor lamp (IOV), introduced in the late-nineteenth century, functioned much as a Coleman lamp used by campers today. In this lamp, kerosene is forced into a vaporizer chamber where it strikes the hot walls of the chamber and is instantly changed into a vapor. This vapor then goes through a series of small holes to a mantle (heated casing or hood) where it burns like a glowing, bright gas ball.[17] This was the last type of oil lamp used before the advent of electricity in lighthouses. Though electricity was first tested in the early 1900s for use in lighthouses, the IOV lamp was still in use up until the 1920s and 1930s in locations that were difficult to reach with powerlines or where generators had yet to be installed. With the coming of electricity to the lighthouses, the jobs of many lightkeepers were eventually eliminated, as the electric lamps were installed in duplicate and the lamp mechanism could automatically move a new bulb into place if one burned out. Electricity made it possible to turn the light on and off automatically. Also with electricity there were no smoke or fumes produced that could cloud the lens in any way. Thus, the keeper only needed to visit the lighthouse infrequently to replace bulbs and wipe the lens, as compared to the daily care the apparatus had required previously.

Light Characteristics

In the eighteenth century, lighthouse establishments had realized that by arranging the parabolic reflectors with lamps in a polygonal fashion, be it a square, hexagon, octagon, etc., and by placing the arrangement on a revolving table, they could create a light with a distinctive "characteristic" that would make it distinguishable from other lights in the area. Fixed lenses were adequate as long as there were no other lights in the area to cause confusion, including city or town lights as well as other lighthouses. But as more buildings were constructed in port cities, particularly buildings whose height placed their lights well above sea-level, and more lighthouses dotted the coastline in any given area, variations in the lights became a critical necessity. Therefore, a majority of the coastal lights were given distinguishing characteristics. As noted by Augustin Fresnel in 1822,

> .... as fixed lights should illumine simultaneously the entire horizon, the same range cannot be had as in revolving or flashing lights, and as they might also be mistaken for others which, through accident or evil intention, might be shown on the coast, the Commission of Lights [France] thought it better to employ only flashing or revolving lights.[18]

The introduction of the Fresnel "bulls-eye" lens (a plano-convex lens used to concentrate light) had provided a characteristic for those lighthouses requiring distinction. By the end of the nineteenth century all lighthouses had adopted lenses in some form. The production of a beam of light from a light source was an inherent feature of the design; all that was further required was a rotating platform on which to arrange the lens panels. The moving platform was initially supported by small brass wheels, and later by ball bearings, with the first and second order lights often supported on mercury floats after 1890.

Other methods had been used to create flashing lights. By revolving a series of solid panels with periodic gaps around the outside of a fixed light apparatus, it could be made to appear as a flashing or occulting light. ("Flashing" and "occulting" refer to the relative duration of light and darkness, a flash being an interval shorter than the duration of an eclipse, and an occultation being shorter than, or equal to, the duration of the light.)[19] As described previously, it was possible to create a flashing light with fixed intervals by revolving a series of vertical annular lens elements around a fixed drum, but this only served to complicate the apparatus and lessen the intensity of the light.

A source from approximately 1876 mentions that occultation by that time was nearly always produced by revolution of the system of lenses and prisms surrounding the lamp, not by the use of screens rotating around the lens system[20]. By using different combinations and sizes of drum and bulls-eye panels, lights could be given varying characteristics. In the mid-nineteenth century, experiments were begun with the use of colors in creating different lighthouse characteristics, as these would be particularly effective in designating a beacon as a lighthouse and not as building or ship lights.

Sound objections were raised against the use of colored lights. Experimentation showed that the majority of colors were quickly absorbed by fog; the one color that seemed effective was red, as the intensity of red light (although not its brilliancy) is actually greater than white light. White light is composed of all colors of the spectrum, and when glass of a certain color is placed around a white light, the glass will only transmit the part of the white light that corresponds to its color (e.g., only red rays are allowed to pass through red glass). Therefore, at the time of transmission much of the illuminating power is destroyed. Use of blue and green glass especially was a problem because the majority of artificial light in the nineteenth century had a yellowish tinge, away from the blue-green end of the spectrum, and thus there were even less blue or green rays to transmit if blue or green glass was used.

Blue and green lights also have less penetrative power in fog, which is naturally yellowish in tint, so it may seem unusual that a green light was chosen for a primary seacoast light such as the Block Island Southeast. But, the decision to make the Southeast Light green did not come about until 1929, when other factors made it acceptable and almost necessary to assign to the light a very distinctive characteristic.

The use of green light (which is closer in the spectrum to yellow and red than to blue) was very infrequent until the early twentieth century. As of 1889, according to David Heap, characteristics consisted of flashes, eclipses, and only red and white light:

> But two colors are used, white and red; the latter color is obtained by using a chimney of ruby glass on the lamp or a pane of red glass outside the lens. Red light penetrates fog better than any other color, and it is for this reason that it is used to the exclusion of the rest.[21]

Flashing lights were further distinguished by the interval of time between the flashes: Boston Light in 1889 was a flashing white every 30 seconds; Gay Head Light on Martha's Vineyard flashed white and red, with 10 seconds between flashes, every fourth flash being red.[22] As late as 1926, George Weiss noted that lights were red, white, and alternating red and white, with no mention of green lights. It may very well be the case that the Southeast Light was one of the first and few lighthouses in the United States to be given a green characteristic.

Lighthouses in the United States

Over time, various different forces have been responsible for the construction of lighthouses in the United States. Prior to the establishment of a federal agency, these duties were assumed locally. They were generally initiated by merchants and/or ship captains in order to facilitate trade, financed by the local government (often through a lottery), and erected and maintained by the people of the area. An example is the Boston Light constructed on Little Brewster Island at the mouth of Boston Harbor in 1714-1716 and believed to have been the first U.S. Lighthouse. As became typical of the day, local merchants had petitioned the General Court of Massachusetts for a lighthouse in this area (allowing night as well as day-time dockings). A lighthouse, they argued, would increase the amount of shipping, while decreasing the amount of shipwrecks, thus boasting the local economy. In order to help finance construction and maintenance, "light dues," a charge based on tonnage, was collected from cargo ships entering the harbor. Twelve such locally sponsored lighthouses were constructed during the Colonial period.[23]

Eventually, it was determined that a regulating agency was necessary to standardize lighthouse practices and insure quality and efficient execution of duties, as well as see to construction and maintenance, etc. Therefore, on August 7, 1789 Congress passed an act assuming to central government the responsibility for aids to navigation. The Treasury Department, under the direction of various officials, oversaw the lighthouse establishment. Although federal regulation was undoubtedly necessary and generally beneficial, there were some drawbacks.

Among the duties assumed by the newly formed lighthouse establishment (later to become the U.S. Light-House Board) was the purchase of lights and all necessary equipment. During the time that the lighthouse service was established, lights were being built with the parabolic reflector system. Due to a lack of support by the Fifth Auditor, the U.S. adoption of the Fresnel system was slow. The Fifth Auditor, Stephen Pleasonton, (influenced by Winslow Lewis,[24] who had a patent on the lamps used with the parabolic reflectors), insisted that the Fresnel lenses were too expensive and that the reflectors were satisfactory. The obvious oversight in the adoption of the Fresnel lens did not, however, go unnoticed. Increasing criticism eventually forced Congress into action.

In March of 1838 a bill was passed by Congress for an appropriation of $15,000 for both a first and second-order Fresnel lens system. These lenses were installed at Navesink Lighthouse in New Jersey (referred to in one 1853 article as the Highlands of Neversink), and their obvious superiority to the reflectors was evident to most. Between 1846 and 1851, while the rest of the world was putting into service over 120 lenses of third or higher order, the U.S. efforts to install Fresnel lenses were put on hold due to lack of funding and disagreement among men in power[25]. Thus, adoption of the Fresnel lens remained slow.

Finally, in 1851 an investigation into the matter was begun by a team of government engineers and Navy personnel. Their findings showed that the majority of the reflectors in use were spherical, not parabolic, meaning that some of the potential light was not being utilized. Therefore, many of the lights could not be seen. It was also found that Tripoli powder was being used on the silver reflectors, despite specific instructions prohibiting its use, as it rapidly deteriorated the polished surface by scratching and wearing.

Due to the investigative committee's report, the Lighthouse Service was taken over by the new Lighthouse Board in 1852, still under the Treasury Department, but now attached to the office of the Secretary of the Treasury. Under the direction of the Secretary, all administrative duties relating to the construction, illumination, inspection and superintendence of lighthouses were discharged. The Secretary also saw to the appointment of an officer of the army or navy assigned to each lighthouse district as lighthouse inspector.[26] The board was composed of engineers and maritime personnel, similar to the investigating team, with the inclusion of an engineering secretary who would be in charge of all fixed aids to navigation, the preparation of plans, specifications and estimates relating to them, and the purchase and repair of the illuminating apparatus. Also under the jurisdiction of the Lighthouse Board was the choice of illuminating device and of fuel. In addition, lightships (which functioned in a manner similar to a lighthouse) were maintained and positioned by the Lighthouse Board as an important part of off-shore navigation. An engineer assigned to each Lighthouse District was under the command of the Lighthouse Board engineering secretary. If Congress made an appropriation for a lighthouse, "the district engineer was charged with the erection of the light, which must be done by contract, if possible, after due advertisement."[27]

Most importantly, the Lighthouse Board voted in favor of replacing the parabolic reflectors with Fresnel lenses, and by 1859 the installation of the lenses in U.S. lighthouses was practically complete. All the lenses used in the United States were manufactured in France by the following government-regulated glass-shapers: Letorneau & Co.; Henry-Lepaute; Sautter, Lemonier & Co.; Barbier & Fenestre; and later, Barbier, Benard & Turenne.

In 1910, the Bureau of Lighthouses under the Department of Commerce replaced the Lighthouse Board. Its duty was to maintain and operate the aids to navigation along the coasts and river channels of the United States and its dependencies. Duties included construction, illumination, repair, inspection, etc. The Bureau of Lighthouses seems to have been the governing body that decided whether to classify lights as primary (for use on coasts and landfalls) or secondary (for use on the inside of capes and other less important points). A 1926 Bureau report indicates that a feature of the primary lights was an IOV or electric lamp usually over 100,000 candlepower; the Southeast Light, although considered to be a primary light, had an IOV lamp of only 50,000 candlepower in 1929.

The era of the Lighthouse Service ended in 1939, when lighthouse jurisdiction was transferred to the U.S. Coast Guard. The Coast Guard has been the controlling body since that time, with a brief transfer of power to the Navy during World War II. During much of the last 50 years, the Coast Guard has been active in upgrading its aids to navigation through automation and more extensive use of other navigational aids, primarily radio signals. The great lighthouse-building era of the nineteenth and early twentieth centuries seems to have come and gone.

PART II - THE HISTORY OF THE SOUTHEAST LIGHT

Located approximately twelve miles south-southeast of the coast of Rhode Island is Block Island; about seven miles long and three miles across at its widest point. At the southeastern tip of the island sits the Block Island Southeast Light. It is part of a ten acre reservation, enclosed with stone walls to the north, south and east with the dramatic Mohegan Bluffs to the west. This is one of a chain of islands which also includes Long Island, Nantucket, and Martha's Vineyard. Block Island was named for the Dutch explorer and trader, Adrian Block, who landed here in 1614. Settlement of Block Island, however, did not began until the late 1600s.[28]

The Block Island Southeast Light is significant for its role in the history of maritime transportation. Throughout its early days Block Island was known as the "stumbling block" for shipping vessels traveling between the Long Island and Rhode Island Sounds. The island marks the first landfall for ships approaching the New England coast from the south or southeast. Thus, the Southeast Light, and accompanying fog signal, have provided an invaluable aid to the navigation of the hazardous waters around Block Island.

The Southeast Light was the second light established on Block Island (the North light having been built previously). The light was exhibited for the first time on February 1, 1875. At that time it was considered to be one of the finest and best equipped lighthouses on the coast. The light is a first-order rotating Fresnel Lens, manufactured in Paris in 1880. The Fresnel lens was then the most sophisticated in lens technology. The Southeast light is one of only a few lighthouses in the United States which still maintains its original lens, while most were replaced by modern lights requiring less maintenance, during station automation.

Site Selection

The first documented acknowledgement of the need to construct a lighthouse at the southeast tip of Block Island came in 1856. In response to a petition from the Collector of the Customs at Newport, Congress appropriated $9,000 for construction of a second lighthouse on Block Island. A year later the Rhode Island General Assembly ceded the land needed for a lighthouse reservation to the federal government. The U.S. Lighthouse Board, however, decided that the money would be better spent in the moving and reconstruction of the existing light at the north end of the Island.

Thus, the true history of the Block Island Southeast Light does not begin until the early 1870's with the efforts of one Nicholas Ball, a Block Island merchant and hotel proprietor. He first attempted to acquire funding for a breakwater, a barrier to protect the coastline from the full impact of the waves, on the eastern side of the island. In the spring of 1870, Nicholas Ball traveled to Philadelphia to obtain the endorsement of their Board of Trade in favor of an appropriation for a breakwater in the Block Island Harbor. While there, Ball had an interview with a Mr. Winslow, then president of the Boston and Philadelphia Steamship Company, whose steamship, "Palmetto," had sunk off the southern shores of the Island in 1858. Due to Mr. Winslow's obvious interest in the installation of navigational aids in this area, he had said he would try to influence the Board in favor of the appropriation for the breakwater as well as a first class light on the south end of Block Island. As stated by Mr. Ball,

> since losing their [the steamship company's] steamer Palmetto on the south end of Block Island in May 1858, they were very anxious for a first class light and fog whistle to be placed thereon, and that he [Winslow] knew of no place where one was more needed.[29]

When still unable to obtain funds for the breakwater project in January of 1872, Ball began seeking an appropriation for a lighthouse at or near the southeast part of Block Island. Ball circulated a petition to shipping firms and other interested businesses in Maine, Massachusetts, Rhode Island, Connecticut, New York, New Jersey and Pennsylvania, requesting the interested parties to sign it and forward it to the Congressmen representing their districts. As stated in the petition, the island was "passed by hundreds of vessels daily" and these vessels were "exposed to as much danger as at almost any other place on the entire coast of the United States." Finally, upon the recommendation of the U.S. Lighthouse Board, Congress appropriated the $75,000 necessary for the construction of a first class light and fog signal in the spring of 1872.

John A. Gardner, U.S. District Attorney of Rhode Island, was sent to confer with Block Island landowners about the chosen site. Despite some initial difficulties, land for the site was purchased from George G. Sheffield, Jr., for $1350.[30] The ten-acre plot of land was surrounded on three sides by a stone wall, with the Mohegan Bluffs acting as the fourth boundary.

Although necessity dictated a light at this site, geologically, it proved not to be an ideal choice for a lighthouse or any other structure. The height of the bluff at the southeast point (approximately 150 feet) makes it a desirable location in that distance above sea level combined with the height of the tower puts the lantern at 212 feet. However, the geological make-up and the rate of erosion of the bluff, it would seem, were not adequately studied. A soil section taken in 1917 by Michael Haltenberger in the Southeast Light area shows the majority of the soil to be diluvium, composed primarily of various kinds of clay, pebbles, and sand.[31] In reaction to this, large boulders of granite have been deposited on the island's beaches in an attempt to prevent the cliff from eroding away.

Factors favoring the lighthouse site, in addition to height, were the availability of a constant water supply for the steam fog-signal boilers and the need to supplement the other lights that were then functioning in the area. Ships approaching New England and the mouth of Long Island Sound from the south and southeast were in need of a means of avoiding Block Island. The only other primary lights in operation in the Third Lighthouse District during the mid-nineteenth century that were helpful towards this end were the Fire Island Light and the Montauk Point Light. These could guide a mariner along the southern shore of Long Island, but another reference light was needed after these, as well as a fog-signal for bad weather.

The Lighthouse Structure - 1873-1988

As was the practice of the Lighthouse Board at this time, the plans for the structure were designed under the direction of the district's Chief Engineer.[32] In the Third District, in which Block Island was located, this was Col. I.C. Woodruff. The actual construction work was advertised and opened for bidding. The contract for the construction of the lighthouse and dwelling was awarded to T.H. Tynan of Staten Island. The contract for the cast-iron superstructure was awarded to Paulding, Kemble & Company for $9,400. The contract for the lantern was awarded to Bailey & Debevoise for $3,448.[33] Final approval of all plans and contractors came from the Lighthouse Board itself, with communications being conducted with the district engineers by the Engineer Secretary of the Board, who at this time was Major E.H. Elliot.

It is unclear from the records on exactly what date the lighthouse construction began.[34] Despite the date stone on the building face which reads 1873, there is evidence that construction did not begin until 1874. Perhaps it signifies the year that the plans were approved by the Lighthouse Board, which we know to be 1873. From a letter dated March 13, 1874, one can deduce that actual construction did not begin until that year; the letter, from Engineer Secretary Maj. Elliot to Third District Engineer Col. Woodruff, reads:

The bids for the erection of a tower and keeper's

> dwelling at [the] mouth of east Point of Block Island, Rhode Island, having been referred to the Board on the 4th instant, it was voted in consideration of the facts presented in your several communications that the contract be awarded to Messrs. M.S. and J.H. Tynan [of Staten Island] for the sum of Thirty-two thousand three hundred and eighty dollars ($32,380.00), the building to be of iron with granite trimmings and you are authorized to enter into contract accordingly.[35]

As the contract was not awarded until March of 1874, we can assume that the construction did not begin until after that time. sA indicated in the 1874 Annual Report of the Lighthouse Board, numerous problems had arisen, putting some strain on the original appropriation funds of $75,000:

> The expenses attending the purchase of the land at this site, district attorney's fees, and the connections with the water-supply, were somewhat greater than was anticipated. This, and the exorbitant cost of hauling the machinery of fog-signal, lumber, labor, &c., have drawn heavily on the appropriation for this station. The metal-work and lantern have to be delivered to the contractors for the dwelling and tower at the site, and the appropriation being all covered by the contracts, no funds remain available for the completion of the reservoir [a reinforcement of the pond on the site]. The sum of $4,500 is asked to meet expenses attending the same.[36]

This additional funding was approved on June 23, 1874, and work resumed.

The Lighthouse Board had issued specifications a for first-order lighthouse brick tower in 1861 and the specifications for a double dwelling in 1862.[37] The design for the Southeast Light seems to have followed these specifications, with some variations. The tower, for instance, specified as being 150 feet, was reduced to approximately 63 feet. This variation was no doubt a result of the height provided by the site itself. In regard to interior workmanship, both sets of specifications provide thorough guidelines for thickness of walls, window sizes, etc.

Designs for lighthouses were generally executed by an engineer under the direction of the Lighthouse District Engineer and thus, were to a degree, standardized. Often engineers transferring from one district to another took their styles of lighthouse design with them; plans for lighthouses were also passed around from one district to another. That is why a lighthouse in Florida may look almost exactly like a lighthouse on the Great Lakes. Some designs were used again and again with only slight variations. This transfer of design seems to have occurred to some extent in the case of the Southeast Light. The 1873 floor plans and elevations of the Southeast Light appear to match those of 1870 for the Cleveland Light in Cleveland, Ohio. They were, however, the only two constructed in this design. The Cleveland Light was discontinued in 1892 and the structure was demolished sometime in the early twentieth century, making the Block Island Southeast Light the only one of its kind.

Although truer to the Gothic form, the light station appears to be a hybrid of the Gothic Revival and Italianate styles, both popular during the period in which the structure was built. The Gothic is seen in its sharply sloping, cross gabled roof, with the slight parapet on the front facing ell, in the unornamented eaves, and the paired windows that extend into the gables. On the other hand, there is an absence of the pointed window arches and verge boards that typically identify the Gothic Style. Italianate features are seen in the paired windows with segmentally arched window heads, and in the entry porch supported by squared beveled posts. However, it lacks the flat roof with the distinctive large brackets in the eaves; the surest mark of an Italianate residence.

The Southeast Light Station consists of a five story brick light tower, connected by a 1-1/2 story hyphen to a 2-1/2 story Gothic Revival, duplex residence with twin 1-1/2 story kitchen wings to the rear. The tower and residence are brick with an ashlar granite foundation and trim. The superstructure of the tower is of cast-iron.

The light tower is composed of an octagonal, pyramidal shaft, a circular cast-iron parapet surrounded by an open octagonal gallery and a 16-sided lantern surrounded by an open circular gallery and capped with a 16-sided pyramidal roof. The tower shaft consists of two brick shells connected by cross walls. The outer shell forms the hollow frustrum of the octagonal pyramid while the inner is that of a cone. The open well is lit by six narrow double hung sash windows topped with segmental arches. The brick shaft terminates at the fourth story in the capital-like superstructure of the parapet and lantern. On the exterior, a cast-iron cornice with a brick frieze provides the molding for eight iron brackets with ornamental spandrels and pendants which support the gallery. At the top of the parapet drum is the 11.5' lantern with 10' windows consisting of three fixed panes on each of the sixteen sides. In the center of the lantern or lens room is the fixed 1000 watt electric lamp which is surrounded by the revolving lenticular apparatus of eight Fresnel lenses, each measuring 39-1/2" by 30-9/16" set in a brass frame.[38]

The residence, joined to the light tower by a perpendicular 1-1/2 story connecting wing at the center of its southeast facade, has a 2-1/2 story main block with two 1-1/2 story rear kitchen wings. The main entrance is located in the northeasterly side of the connector (a second on the southwesterly side has been replaced by a window). To each side of the connector on the main block is single story porch. The porch posts on the southwesterly side retain their decorative beveled, bracketed posts while the balustrade, and the entire porch on the other side, has been replaced with plain squared posts and balustrade. The fenestration of the facade consists of two 3/4 length 9-over-9 pane windows on the first story, with a 4-over-6 pane, centrally located wall dormer with segmental arched window head. There are identical dormers over the entry doors. The gabled ends of the main block consist of two pairs of 6-over-6 pane windows on the first and second floor, and one pair of 4-over-four panes on the half story. The kitchen wings to the northwest rear are connected to the main block by a single story, shingled frame passageway. Each wing is lit by one pair of 4-over-6 pane windows and a single 2-over-2 pane window in its outer wall and a single 6-over-6 pane window in its inner wall. The kitchen garrets are lit by flanking 2-over-2 pane windows to either side of the chimney block in the gable end.

The Annual Report of 1875 tells us that the Block Island Southeast Light station was completed and the light was first exhibited from the tower on February 1, 1875. In the years since its completion, the structure has seen very little change. Most of the alterations that were made were a matter of general maintenance or modernization. The significant changes that have taken place are in the light apparatus itself, not in the building.

One of the earliest major repairs to the Southeast Light station came in 1886 when the original shingle roofing was replaced with slate. Several appropriations were made in the early 1900s for general repairs, including re-shingling of the roof with asbestos (1923), new higher chimney tops (1933), and the installation of indoor bathrooms (1938). This last endeavor resulted in one of the few changes in the original floor plan. Two bathrooms were put in place of the second floor keepers' workroom in the connector, and a third bathroom was partitioned off on the first floor, eliminating the entryway on the west side of the building. Also in 1938, major repairs to the chimneys and roofs, plus interior repairs necessitated by water damage, were required after the hurricane of September 21 of that year.[39] Many of the repairs or internal alterations since the 1930s have been associated with storm damage or updating the structure internally with modern plumbing and electrical conveniences. None of these improvements, however, altered the outward appearance of the building.

As seen from the east in 1988, the exterior appearance of the lighthouse had changed with the addition of steel fire escapes to the outside of the living quarters, and replacement of the original, more ornate front porch balustrade with one more plain. From the west, the exterior had been altered by fire escapes as well, and the original door leading from the porch into the interior had been replaced with a window.

The Lens and Lamp System - 1873-1988

Some of the most significant changes at the Southeast Light have been made to the apparatus that makes the light a primary aid to navigation - the lens and lamp assembly. The Southeast Light was intended for use as a primary seacoast aid to navigation, and thus was equipped with the largest Fresnel lens, the first-order. It was the decision of the Lighthouse Board to assign the light a fixed white characteristic, and the lens apparatus was then purchased from the glass shaping firm of Barbier & Fenestre of Paris for the sum of $10,000. At the Southeast Light, it was unnecessary to illuminate the landward side of the lantern; therefore, instead of the traditional eight panel first-order lens assembly (in which each panel is responsible for 45° of coverage), the Southeast light required only six lens panels, covering 270°.

A copy of the original packing slip filed at the Third District office on December 20, 1873, indicates that the lens arrived in the United States prior to the building of the lighthouse. The slip is marked specifically for Block Island, and also mentions that it is a 270° lens, rather than one that illuminates 360°. Instead of leaving the two landward panel spaces empty, the Southeast Light used a method of collecting the posterior light rays, as described by Leonce Reynaud:

> When an apparatus is not required to illumine the entire horizon, it is important to direct to the sea the rays which would diverge uselessly toward the land side. For that purpose recourse is had to spherical reflectors, which cover the dead [landward] angle of the apparatus and return to the focal point the rays which come in contact with them.[40]

In the case of the Southeast lens apparatus, the drawing shows that the two reflecting panels were composed of prisms set at such angles to the lamp as to utilize the properties of total internal reflection in a prism. By using glass as opposed to a metallic reflecting surface, more light was made available for the beacon, as metallic surfaces had a tendency to absorb more light than glass and reflect more light at useless angles. The position of each prism was calculated so that the reflected rays would not cross each other at the exact focus (the lamp), but slightly higher. Thus the reflected light would not be absorbed by the body of the lamp, and the burner would not overheat, which could cause the wicks to char or possibly fuse.[41]

The first lamp at the Southeast Light was a four-wick Fink's Hydraulic Float of 12,188 candle power, a type of lamp which could be used where only a part of the horizon required illumination.[42] On a four-wick lamp, the diameter of the outer circular wick was 3.5", the inner wicks being 3.0", 2.5", and 7/8". The lamp first used lard oil, later adopting kerosene when that fuel became popular in the 1880s. The oil was stored initially in drums on platforms in the base of the tower.[43] The four-wick lamp remained in use until 1889, when it was replaced by a five-wick lamp (candle power unknown).

Various authors of the 1880s described the Southeast lens in their commentaries of Block Island, giving us further information on the appearance of the lens assembly. Reverend Samuel T. Livermore's History of Block Island (1877) tells how six people were able to stand inside the lens arrangement at one time.[44] In Block Island Illustrated, with Descriptive Sketch (1884), Edward E. Pettee notes that the lens uses a "cylindrical hoop of glass as a refracting lens, above and below which are separate glass prisms of triangular section, placed at proper angles to reflect and refract the light," with the result that "all the light is made to finally pass out in rays parallel to those of the central lens;" "the whole is arranged in the form of a hollow cylinder, narrowing at the top and bottom, twelve feet in height and six feet in diameter."[45] Pettee's account reinforces the point that the first lens assembly installed in the Southeast Light was a fixed light.

According to Pettee in 1884 the four-wick lamp was burning lard oil at the rate of 900 to 1000 gallons annually, all of which were stored in tanks in the oil room in the base of the tower. During the winter, he reported that the lamp consumed 2 1/2 gallons of oil nightly. The five wick lamp installed in 1889 burned a 1/2 gallon of oil hourly, according to the Providence Journal of July 21, 1889, which did not indicate whether this was an average rate for an entire year. The next change made in either lens or lamp (other than alterations in choice of fuel) came on February 12, 1907, when the five-wick lamp was replaced by an incandescent oil vapor [IOV] lamp of 45,690 candle power.

In 1888, the Lighthouse Board Annual Report listed Gay Head

Light (Martha's Vineyard, Mass.), Sankaty Head Light (Nantucket, Mass.) and Montauk Light (Long Island, N.Y.) as the other primary lights in the vicinity of Block Island. As described in The Lighthouses of the World and Coast Fog Signals (1896 ed.), Montauk and Sankaty were fixed white with a single flash (Montauk once every two minutes and Sankaty a ten second flash every minute). The white, primarily steady appearance of these lights made them very similar to the fixed white of the Southeast Light, whereas Gay Head was a flashing red and white light, thus easier to distinguish. A fourth light, the fixed first-order light of Great West, or Shinnecock Bay, Long Island, was exactly the same as the Southeast Light in 1896.

It may have been confusion with other area lights that led in 1929 to a major change in the lens assembly of the Southeast Light. Plan #7276 on file at the Office of the Superintendent of Lighthouses, Third District, Staten Island, N.Y., 1928, gives the layout of the intended lens and lens pedestal change. The plan indicates that the new assembly would be a revolving apparatus with bulls-eye Fresnel lenses, creating a flashing as opposed to a fixed light. This assembly was intended to have only four flash panels, interspersed with four blind panels; the duration of the flashes and eclipses was dependent on the speed at which the lenses would revolve around the light source.

When this new system was put into operation in 1929, various other changes were made in conjunction with the new flashing characteristic. First, the characteristic color of the lens was changed from white to green, making the Southeast Light the only first-order green light in New England.[46] The green beacon was achieved by placing a shade of colored glass around the light source. Second, the light source was also updated at this time to a Type A, 55 millimeter IOV lamp (kerosene burning) of 50,000 candle power.

The addition of a mercury float for the rotating lens assembly was a third change made at the Southeast Light in 1929. In the words of J.A. Purves:

> The development of the modern system of lighthouse apparatus and illumination may be said to have originated in the mercury-float mechanism, devised in 1890 by the late Monsieur Bourdelles, Director-General of the Central Lighthouse Service of France.[47]

The mercury float provided a means of rotating a heavy apparatus on something other than ball bearings and "chariot" wheels, both of which succumbed rapidly to wearing by friction caused by the large size and weight of the apparatus. As described by Purves:

> In place of the roller or ball bearings employed in the past for revolving apparatus, an annular trough is employed, in which there floats a second annular trough, on which is carried the dioptric apparatus. In order to steady the revolving superstructure, and to render it capable of a certain amount of adjustment, a vertical spindle projects downward from the apparatus through the mercury trough to some distance below it, and is supported and guided upon suitable bearings.[48]

Due to the density of mercury, only a thin film (approximately 1/16 to 1/8 inch) is required between the two troughs in order to provide a surface on which the assembly will glide or float.[49]

After the major change from fixed white light to flashing green in 1929, a change that came after 54 years of the light existing in its original form, the next alteration was made in a relatively short span of time. A proposal to increase the candle power of the light was made in an April 29, 1931, "Recommendation as to Aids to Navigation;"[50] by changing the 55 millimeter IOV lamp to a 1000 watt P.S. 52 clear, 115 volt C7a filament lamp, the candlepower would be increased from 50,000 to 169,000 candle power. As reported by District Superintendent J.T. Yates, the change in lamp would also change the duration of the flash from .030 seconds to .168 seconds.[51] Whether or not the lamp-change was carried out at this time is unclear.

The next clue we have to an alteration made in the lens assembly comes from a "Recommendation" made on March 7, 1933, which reads as follows:

> The present flash of light is too quick to be readily picked up and it is proposed to lengthen the flash by installing four additional dioptic [sic] sections of a 1st order lens, on hand, and cut the revolutions of lens from 4 to 2 per minute thereby doubling length of flash. The candlepower is not changed. The length of flash (taken at 50% of peak C.P. and 2 R.P.M. of lens) is 0.3 sec. and 3.45 sec. eclipse. The apparent discrepancy with the present flash of 0.2 sec. was due to fractions, the .2 flash being slightly more than actual.[52]

It is interesting to note that four more dioptric panels were already on hand at the site, which brings up a point worth mentioning at this time. As the lens was found in 1988, three of the lens panels were manufactured by Henry-Lepaute of Paris, but the other five are stamped with the trademark of L. Sautter & Co., Paris. All of the panels have numbers in the lower corners of the frames that indicate which lenses were to be paired when assembling the apparatus; inspection of these number pairings on the Southeast lens in 1988 revealed that few match. One of the lenses manufactured by Henry-Lepaute is stamped with the date 1880. We know from the historical evidence collected that the Southeast Light was fixed white in 1880, so the dated flash panel must have been used elsewhere before its 1929 (or 1933) installation in the Southeast Light. The most probable hypothesis is that some, or all, of the flash panels were "cannibalized" from other discontinued first-order lights, which would account for the different manufacturers' stamps and inconsistent matching of the frame numbers. No records were discovered which indicated previous locations of the lens panels.

Correspondence from Junior Lighthouse Engineer, Ellis Gordon and Keeper, Carl F.W. Anderson, to the District Superintendent in 1933 indicate that the change in characteristic was a vast improvement. Gordon comments that the increase in the length of the flash also seems to have increased the intensity of the light. Both men remark on the many favorable comments that they have received from the "boatmen" on the ease with which the Southeast Light can now be seen.[53]

No other changes were made in the lens apparatus after this time, although several recommendations were made concerning maintenance of the lens and mercury float. In 1939, the Lighthouse Service was absorbed by the U.S. Coast Guard; the boundaries of the lighthouse districts were changed, and the Southeast Light became part of the 1st Coast Guard District.

One significant request for work authorization in 1947 almost marked the end of the Southeast Light's Fresnel lens. On January 9 of that year, the commander of the 1st Coast Guard District requested that a Crouse-Hinds double drum 36" rotating green beacon of 190,000 candle power be sent to the lighthouse site to replace the first-order Fresnel light then in use. The request notes that the Southeast Light was then using a 1000 watt, 120 volt T-20 2-C-5 filament clear mogul base lamp, operating at 170,000 candle power, and the lens was driven by a hand wound, side drive, type C lens clock. The fate of the Southeast Light if this action were carried out? As described in the form:

> [The] 1st order lens and pedestal will be dismantled, crated and shipped to C.[oast] G.[uard] Base, Constitution Wharf, Boston, for storage or as Headquarters may direct. I request Headquarters instructions as to whether this lens and pedestal be surveyed for crating and storing, crating and sale, or be destroyed at the site.[54]

The reason for installing the Crouse-Hinds was to provide a beacon for both sea and air navigation, whereas the Southeast Light, by design, was most useful only for sea navigation. In 1950, a letter concerning the proposed change was addressed from the 1st District Commander to the Commandant. In his letter, the commander presents an alternate plan for the Crouse-Hinds beacon, stating that the district files do not contain any correspondence which would indicate that a navigational aid suitable for both sea and air navigation is specifically needed in the immediate vicinity of Block Island. He proposes to place the unit at Gay Head Light instead, for the following reasons:

> a) The first order mercury mounted lens at Block Island Southeast is <u>in excellent condition and should operate indefinitely without any major repairs</u> (M. Thomas, HAER emphasis). This aid is entirely satisfactory for surface navigation.
>
> b) The ball bearing mount for the Gay Head lens is a constant source of maintenance trouble caused by excessive wear of the ball races....
>
> c) Gay Head Light is not now electrified.... It would then appear that here is the opportunity to eliminate a serious District maintenance problem [Gay Head Light] and, at the same time, provide an improved aid to both sea and air navigation.[55]

This alternate plan was accepted; a communication of March 23, 1950, instructs the Officer in Charge at the Block Island Southeast Light Station to ship the Crouse-Hinds Lighthouse Beacon equipment from Block Island, where it had been stored in anticipation of installment, back to Boston. And so the Southeast Fresnel lens was saved to shine another day.

After this threat passed, mention of the Southeast Light appeared in Coast Guard correspondence primarily for minor maintenance actions, more often involving the dwelling structure and the outer buildings than the lens and lamp. A Coast Guard recommendation was made in 1954 to strain and clean the mercury, and give the light a "complete overhaul," the meaning of which is not made clear. Sometime after 1947 the light source was changed to a 1000 watt, 120 volt, Q 1000 T-20-BP Mogul Bipost lamp emitting 237,000 candle power.[56] This equipment was still in use in 1988. In case of a bulb burn-out there is a trigger arm with fresh bulb that will be moved into place automatically.

By 1988, the bull's-eye Fresnel lenses had been in service at the Southeast Light for 59 years without serious mishap. In that period there were several major hurricanes that damaged the outer structure, including the lantern room roof, but the lenses survived intact, suffering only minor cracks that may also be attributed to shifting and flowing of the glass with time.

The Fog-Signal

The first fog-signals in the United States were a far cry from the sophisticated electronic warning signals of today, but nevertheless their use undoubtedly saved many ships from certain destruction. As noted by George Weiss, the first U.S. fog-signal installed at Boston Light in 1719 was a cannon fired when necessary to answer the signals of ships in thick or foggy weather, rather than being fired at regular intervals to warn ships. This initial use relieved the keepers of a responsibility that later keepers would have to bear when it became normal practice to sound the signal periodically (for instance, every half-hour) during foggy weather.

Use of cannons ceased as later signals took the form of bells, trumpets and, eventually, steam whistles (1857) as the usage of steam technology progressed. A type of steam siren, first employed at the Sandy Hook East Beacon in 1868, was initially used at the Block Island Southeast site. The fog-signal structure was the first building completed at the lighthouse location. As noted previously, the need of a water supply for the fog-signal had been a primary consideration when selecting the site. Water for the signal was drawn from a pond approximately 400 feet northeast of the signal house. Essentially, a fog-signal can be just as important as a light because it can be used in both clear and foggy weather, whereas a light is useless in foggy weather. However, at times it can be difficult to determine the direction from which the fog signal is coming. Also, due to site location, the range of some fog signals may have blocked areas referred to as "dead zones" where sound waves cannot travel. The site of the Southeast light evidently lent itself to the use of a fog signal since it was the first structure erected at the Southeast Light station. A consideration was probably also the lesser effort of establishing a fog-signal in comparison to constructing a lighthouse, as well as the high incidence of fog here.

In 1875, the Southeast fog-signal was put to use in experiments on the abnormal phenomena of sound in connection with fog-signals, conducted by Prof. Joseph Henry, chairman of the Light House Board and director of the Smithsonian Institution. In his experiments, steamships sailed closer to and farther from the island at various headings, under a variety of weather conditions. The results indicated, essentially, that varying air currents affect the duration and direction of the sound projected by fog-signals. Because of these demonstrated aberrations in the transmission of sound, mariners are often warned to not rely heavily on the warning of fog-signals, but to regard them only as auxiliary aids.

The fog-signal equipment, housed in a frame structure, was described in the Providence Evening Bulletin of 13 September 1873 in the following manner:

> The building is 15 x 30 feet, with twelve feet posts. The whistle is a reed instrument of Brown's patent, and makes two blasts per minute. A cistern has been dug near the building, twelve feet in diameter and twelve feet deep, for a back reservoir in case of a dry time. A well is also to be sunk for a similar purpose. The water ordinarily is to be obtained from a pond near there [still in existence as of 1988].

Nicholas Ball's records show that he was not particularly pleased with the location of the fog-signal house or with the site selection in general. He believed that the fog siren whistle did not throw its sound westward far enough for vessels to hear in time to prevent their running aground on the western shores of the island. In Ball's opinion: "It would have been much more satisfactory if the light and whistle had been erected on a bluff just opposite Black Rock [Southwestern Block Island; see Sheet 2 of HAER Measured drawings]."[57]

The 1873 fog-signal apparatus consisted of a four-horsepower boiler and seventeen-foot cast-iron trumpet, with a brass siren placed at the small end of the trumpet. A duplicate set of equipment was installed in the building in case of the failure of the first. Thus, the second set included its own boiler so that it would be entirely independent of the first. The seaward end of the trumpet was approximately five feet in diameter. Within the siren at the small end of the trumpet,

> the sound is produced by the rapid revolutions past each other of two flat discs pierced with a great number of small holes. A jet of steam under high pressure is projected against the discs, which revolve past each other more than a thousand times a minute. As the rows of small holes in the two discs come opposite each other, the steam vehemently rushes through, and makes the singular and piercing noise which the siren gives forth.[58]

Improvements in fog-signal technology soon made this design obsolete. By 1906, the steam siren had been replaced by a first-class compressed air signal powered by kerosene engines.

On the morning of April 28, 1908, the Third District Engineer reported that the frame fog-signal house at the Southeast Light had burned to the ground, according to Head Keeper, Simon Dodge. Although an unfortunate occurrence, this opened the way for new technology at the site. The old engines were replaced with new 13 h.p. Hornsby-Akroyd oil (i.e. kerosene) engines and the innovative Bowser system of oil handling machinery was installed. The Bowser system stored the oil in two tanks, one for the lamps and the other for the fog-signal, in a convenient cellar or oil-house at a safe distance from the tower, from where pipes led to two measuring pumps, one in the watchroom of the tower and the other in the engine room of the fog-signal house. The system eliminated carrying of oil, and the oil drawn off was measured by gauges on the pumps. Evaporation, leakage and odors were also prevented by the Bowser system.[59]

The fog-signal with its new engines was housed in a slightly different arrangement when the fog-signal house was rebuilt in 1908. Specifically, the sirens of the system were re-located to the roof of a separate small building 100 feet southwest from the new brick building, which was now the engine house. In 1913 the sirens were moved from the separate structure and mounted on the engine house because the partially exposed air pipes between the engine house and the siren house experienced problems in cold weather that inhibited the performance of the signal.[60]

In 1915, a general improvement in fog-signals (not necessarily at the Southeast site) was made when the revolving plate in the siren was replaced by a cylinder with peripheral slots (rotor), which was enclosed in a casing also with slots, leading to a horn or trumpet. The rotor could be driven mechanically or automatically by air or steam pressure. The compressor-type signal, driven by internal combustion engines, was easier to start than the whistles, and had a greater distinctiveness of note. As of 30 June 1925, there were 543 United States fog signal stations, primarily on the Atlantic Coast.

The Block Island Southeast fog-signal equipment changed again in 1934, when the siren was replaced by a Typhon diaphragm horn. The Typhon horn had a vibrating metal diaphragm operated by a system of valves and differential air pressure; the vibration was transmitted to resonators that emitted the sound. This type of signal remained in use at the Southeast Light until 1974, when it was replaced by an electronic fog-signal installed directly on the lighthouse tower, still in use as of 1988 (see HAER measured drawings, sheet 12).

The compact electronic fog-signal (far different from the seventeen foot trumpets on the 1873 signal) uses a vibrating diaphragm to produce sound. A metal plate between the pole pieces of a magnet vibrates as an alternating current passes through metal windings around the magnet. Due to its vertical arrangement, the signal concentrates the propagation of the sound wave in a horizontal direction rather than in a vertical direction, which would waste the sound vertically above the surface of the water.

In accordance with an Operations Bill issued by the Coast Guard in 1962, the specifications for turning the fog-signal on are that it "shall be operated when visibility due to fog or other atmospheric conditions is less than 4.1 miles, that is, when Block Island Southeast Lighted Whistle buoy becomes obscured due to conditions stated."[61] The fog-signal produces a five-second blast, followed by a 25 second silence. As soon realized by the author of this report in the summer of 1988, these conditions exist a great deal of the time and the fog-signal is therefore often in operation.

Other Structures

The technology of aids to navigation went beyond beacons and fog-signals with the introduction of radio signals in the early twentieth century. Subsequently, structures were built at the Southeast Light to accommodate these changes. Also, it must be remembered that the Light functioned as a residence for several families. Various out-buildings were constructed to meet the needs of daily life, including barns during the carriage days and, later, garages for the new horseless carriages.

One of the first new structures recorded at the site appeared in 1898, when the U.S. was at war with Spain. From April 23, 1898, until July 31 of that year, a detachment of naval personnel was stationed at the Southeast Light, where they constructed a 90-foot mast with a 40-foot cross yard from which signal flags were hung. A small dwelling structure (12 x 20 feet) was built 100 feet northwest of the signal mast, which is presumed to have been on the highest point of ground on the property, somewhat north of the lighthouse.[62] In 1899, after the signal station had been abandoned, requests were made to remove the station to the shore end of Block Island's Great Salt Pond.

In 1899, a telephone was installed at the Southeast Light, although it could first be used only from the Southeast Light to the North Light and the Life-Saving Stations. The telephone was followed shortly by the telegraph in 1903. The telegraph equipment and building, as well as a complete newspaper printing office, were situated near the Southeast Light and were used in the publication of the Block Island Wireless, published by the Providence Journal Company. According to the Providence Journal:

> The day's news will be telephoned from the office of the Providence Journal Company to the Journal company's wireless station at Point Judith [Rhode Island] and from there it will be hurled through the air and "picked up" by the island station.[63]

The Block Island office was later used as a residence.

Radio signals were first installed at lighthouses in 1921. By using these signals, navigators could locate the position of their ship by taking cross bearings on two or more radio stations, or by repeated bearings on the same location with the distance logged between the bearings. The advantages of radio signals over lights is obvious; radio waves transmit farther than light rays can be seen, and radio can be used in bad weather. The apparatus usually consisted of a commercial, panel-type spark transmitting set of approximately one kilowatt of power, with a timing signal for producing the desired signal at regular intervals. The signals themselves were kept simple to avoid confusion.

It is assumed that the installation of radio equipment at the Southeast Light took place in 1931, as a Providence Journal article of December 1936 marked the fifth anniversary of the radio beacon. In the government publication "Notice to Mariners" of February 13, 1948, the following information is given to navigators:

> Effective at 1200 on 12 February, 1948, the radio beacon at Block Island Southeast Light Station was changed to provide for continuous carrier operation during the entire radiobeacon minute with keyed modulation. The beacon operates 1 minute on, 2 minutes off, continuously 24 hours daily. There is no change in operating frequency or characteristic.[64]

An "Aids to Navigation Operation Bill" (U.S. Coast Guard) of April 17, 1962, says that the radio beacon range was then 100 miles and the signal characteristic was two dots, a dash, followed by another dot (. . - .). This morse code signal can be used by mariners and aircraft alike. In 1988, the radio was operating on a carrier frequency of 301 kilohertz, range 20 miles, and transmitting the morse code signal for Block Island (B I: - ... . .) for 50 seconds followed by a ten second steady tone. Several tower structures have been constructed, ending with the tower used in 1988 that, as seen from the HAER drawings accompanying this report (site development maps, HAER measured drawings sheet 3), was several feet northwest of the abandoned brick fog-signal house.

A radar station was erected on the property in 1943 for use in World War II; it was placed on a high point of land north of the lighthouse structure.[65] A request to demolish the remaining structures was submitted by the keepers to the District Commander in 1962. All that remained of the station in 1988 were the foundations.

The majority of the barns and garages that have been on the site were frame buildings, as seen in old photographs. The business of keeping animals on the property probably ended with the absorption of the Bureau of Lighthouses in 1939; the keepers after this time were no longer civilians who had lived on the island most of their lives, as previously. One record that we do have of construction on out-buildings dates from January of 1939:

> The old barn which was used as a garage and the old storehouse were destroyed by the storm of Sept. 21, 1938. It is proposed to replace these buildings with a combination garage and store house building, the building to be of brick and in accordance w/ Drawing no. 8367.[66]

Permission was granted on February 28, 1939, for Frasca Construction Company to build a 3-car garage and storehouse at Block Island.

The ranch house that appears on the site maps of 1988 was built in 1962 to house a Coast Guard lightkeeper and family. A request was also made by the keepers in 1962 to remove a fence in front of the ranch house that had been placed there by the International Nickel Company; the fence had been used at one time to test metals and paints for exposure to salt air, wind, etc. Permission was granted to demolish the fence.[67]

Conclusion

The Block Island Southeast Light has captured the imagination more than almost any other light on the New England seacoast. Since 1877 when the Light was mentioned in Livermore's History of Block Island and described in a Block Island tourist guidebook by "Ben Mush" of the Norwich Morning Bulletin, the Southeast Light has been a Block Island tourism landmark.[68] The lighthouse's picturesque Gothic Revival architectural styling and its dramatic location, 150 feet atop the Mohegan Bluffs, make it a continually intriguing site.

Of interest from the standpoint of the history of technology, the original light apparatus can still be used as an aid to navigation; the optical principles on which the lens assembly was based have not changed with time. Some changes, however, have been made. The major site and technological changes at the Southeast Light have of course followed the progress in lighthouse technology. These can be broken into specific periods to economize the changes, beginning with 1873-1900. In this time period, the station was built and put into operation, and the lamp went from four to five wicks. From 1900 to 1925, most of the alterations involved the fog-signal, which changed from steam to compressed air. The fog-signal structure changed from frame to brick (1908), had two separate structures from 1908-1913, and then one structure after that. The lamp for the light was changed to an incandescent oil vapor lamp in 1907.

Between 1925 and 1950, both the lens assembly and the fog-signal were changed, although neither resulted in major structural changes to their respective buildings. In this time period, the lens system was changed from fixed white to flashing green (1929-1933), which included the replacement of the fixed drum lens with an assembly of first 4 then 8 revolving flash panels. A new electric light source was also added in this time. The fog-signal, still housed in the brick structure, was changed to a Typhon diaphragm horn in 1934. The installation of radio signalling equipment by 1931 changed the appearance of the site with the addition of several metal skeleton towers.

From 1950 to 1988, the lens remained unchanged. The fog-signal house was abandoned in 1974 when a compact electronic fog-signal was placed on the outer platform of the tower lantern. The major changes in the appearance of the site came from the building of the ranch house in 1962, and the continuing erosion of the bluff.

What will be the fate of the Southeast Light in the coming years? Because of the eroding Mohegan Bluffs on which the lighthouse rests, the building faces an uncertain future. As depicted on HAER measured drawings, sheet 2, much of the original cliff edge has fallen away, including a 10-12 x 50-100 foot section since 1982. A geological report compiled by LeMessurier Associates, Inc., of Cambridge, Mass., in 1985 cites four erosion forces at work: direct rainfall runoff, indirect rainfall runoff (from the land above the bluff), seepage erosion (erosion caused by springs breaking out in the face of the slope as a result of water seeping horizontally along sand and gravel layers to the point where they are exposed at the face of the bluff), and wave erosion of the lower bluff. The final conclusion of the report was that the erosion could be retarded by slope grading, application of drainage nets, etc., at a cost of $2,275,000.[69]

A second alternative to insure a solid future for the Southeast Light is a suggestion to move the lighthouse back from the edge of the bluff. Efforts were being made in 1988 by the newly established Block Island Southeast Light Foundation, Inc. to raise funds for such a move. Feasibility studies have shown that the project would cost approximately $2,500,000. On October 13, 1988 a bill was put forth to the U.S. Senate to authorize the Secretary of the Department of Transportation, under which the U.S. Coast Guard operates, to convey the light to the Block Island Southeast Light Foundation. This would enable the Foundation to establish and maintain a nonprofit center at the lighthouse for two purposes. The first would be to raise funds to move and restore the threatened lighthouse. The second purpose would be to interpret and preserve the material culture of the U.S. Coast Guard and the maritime history of Block Island.

For now, however, the fate of this lighthouse is uncertain. As of 1988, there were only nine manned lighthouses (periodically checked by a Coast Guard Lightkeeper, although not necessarily on a daily basis), all other lights having been replaced by automated beacons, with the Fresnel lenses of the discontinued lighthouses either put in storage or sent to museums, or broken to salvage their metal frames. The Lighthouse is presently serving a dual purpose as an aid to navigation for the hundreds of mariners who daily pass safely by the "Stumbling Block" with the help of the Southeast Light and fog-signal, and as a museum exhibiting various artifacts from Block Island history, with a focus on the history of the Southeast Light. Through the efforts of the Southeast Light Foundation (and similar institutions elsewhere) people will be reminded of the historical significance of lighthouses, and of Augustin Fresnel's wedding of science and technology. The Southeast Light exemplifies the fruits of that marriage.

<u>PROJECT INFORMATION:</u>

The Block Island Southeast Lighthouse recording project was initiated and funded by the United States Coast Guard in compliance with the 1985 Amendments to the Historic Preservation Act of 1966. Sally K. Tompkins, Deputy Chief, HABS/HAER, coordinated the project and Richard K. Anderson, Jr., HAER Staff Architect, served as project leader. The recording team consisted of historian, Mary M. Thomas (University of Notre Dame), architectural field supervisor, Mabel A. Baiges (Kansas State University), and architectural technicians, Patricio del Real (Washington University) and Lee Ann Jackson (Auburn University). Martin Stupich was contracted by HAER to take large format photographs. The history was edited by Richard K. Anderson and Catherine C. Lavoie before being prepared for transmital to the Library of Congress. The photographic captions were written by Richard

Anderson, and the drawings edited by Richard Anderson and Isabel Yang of the HAER office in Washington.

ACKNOWLEDGMENTS:

HAER wishes to acknowledge the assistance of the numerous individuals and organizations in the production of the historical report and measured drawings for the Block Island Southeast Lighthouse recording project. Dr. Robert Scheina, historian, and Lt. Commander Robert Garrett, Aids to Navigation of the Washington Headquarters of the U.S. Coast Guard were instrumental in the funding of the project and in the selection of the Southeast Light for documentation. The project was intended to be the first in a series of such projects for the documentation of significant lighthouses operated by the Coast Guard, and as a pilot project, it was also intended to be one of many events marking the 200th anniversary of the Coast Guard's service in the United States. Mr. Douglas Sundstrom, archivist at the Coast Guard's Shore Maintenance Detachment at Governor's Island (New York), was of invaluable help in securing copies of original drawings of the Southeast Light's site plans and lenses as well as various other historical records. Drawings of the building were also provided to the HAER team by Dr. Gerald Abbott, a director of the Block Island Historical Society and the Block Island Southeast Light Foundation, Inc. Boatswain Mate 1st Class (BM-1) Steven Koskinen, lightkeeper at the Southeast Light at the time of the project, was also of aid in locating documents related to the facility's more recent operations.

Considerable historical research on the Southeast Light was performed in advance of the project at the National Archives, the Library of Congress and the Smithsonian Institution in Washington, D.C. by Catherine C. Lavoie, HAER staff Historian. The voluminous research of Pamela Littlefield and Robert M. Downie, both of the Block Island Historical Society, was invaluable to HAER, since the materials they had collected or written about Block Island and the Southeast Light saved many weeks of research. Technical information on the history, design, and construction of Fresnel lenses was collected by Richard K. Anderson, Jr., HAER staff architect, and further research was conducted by Mary M. Thomas, project historian, who also wrote the history of the Southeast Light during the project. The Block Island Historical Society provided housing to the recording team and gave generous access to their society's records for the purposes of the project.

During 1988, considerable consultation occurred between the Block Island Historical Society, the U.S, Coast Guard, and the office of U.S. Senator John Chafee regarding the disposition of the

Southeast Light building and its operating Fresnel lens. While activity to transfer title of the building from the Coast Guard to the Block Island Southeast Light Foundation, Inc. had gone on for years, the Coast Guard's ongoing program to automate the lighting equipment at its lighthouses threatened the removal of the ca. 1880 Fresnel lens from the building in 1988. During the summer of 1988, a compromise was reached--the new light equipment is to be erected on a separate steel tower, and the old lens left inoperative in the lighthouse for exhibit. At the end of 1988, a bill had been submitted to the U.S. Senate by the Honorable John H. Chafee of Rhode Island to transfer title of the Southeast Light to the Block Island Southeast Light Foundation, Inc. in order that the foundation may open the building as a museum. The foundation's immediate plans are to raise funds for moving the building several hundred feet back from the eroding edges of Mohegan Bluffs to avoid its eventual destruction. It appears at this writing that Congress may even underwrite the moving expenses for the lighthouse.

APPENDIX

RECENT PRINTED ITEMS THAT FEATURE IMAGES OF

BLOCK ISLAND'S

SOUTHEAST LIGHTHOUSE.

BOOKS:

BLOCK ISLAND SUMMER, 1972, p. 98, 100, and cover. (photo)

MARINE PHOTOGRAPHY OF PETER BARLOW, 1972; p. 31. (photo)

BROCHURES:

CHAMBER OF COMMERCE, Block Island, map directory, 1970's; photo.

CHAMBER OF COMMERCE, Block Island; map directory, 1980's; drawing.

NATIONAL HOTEL, Block Island, 1983-5; photo.

NATIONAL HOTEL, Block Island, 1986-7: photo.

RHODE ISLAND DEPT. OF ECON. DEV., "WELCOME TO R.I.", photo, cover.

RHODE ISLAND TOURIST GUIDE, 1973; photo, cover.

MAGAZINES:

ADVENTURE ROAD, Summer 1983; photo, p.3 & 20, 21.

BETTER HOMES AND GARDENS, March 1987; R.I. ad & photo, p. M-7.

BOATING, July 1980; p.51, photo.

FORD TIMES, June 1968; painting, p. 12.

KEEPER'S LOG, Vol. 2, No. 1, 1985; p. 20 (drawing), p. 30 (photo).

MOTOR BOATING 7 SAILING, June 1971, p. 50, 51, photo.

NATIONAL GEOGRAPHIC, Sept. 1968; p. 382, 383, photo.

NEW YORK, April 28, 1986; photo, cover.

ON THE SOUND, June 1971; photo, p. 39.

ON THE SOUND, June 1973; photo, p. 52.

YACHTING, March 1984; photo, p. 89.

YANKEE MAGAZINE GUIDE TO NEW ENGLAND, Summer 1980; photo, p. 180.

MISCELLANEOUS:

HARBOR LIGHT, B.I. First Baptist Church; newsletter masthead.

NATIONAL TRUST FOR HISTORIC PRESERVATION, 1985 program, rear page.

NEW ENGLAND TELEPHONE, White Pages, 1972, photo cover.

RHODE ISLAND STATE ROAD MAP, 1985/86; photo.

WASHINGTON TRUST COMPANY, bank newsletter, Summer 1984; cover.
[Welcomed the bank to its first office on Block Island.]

SAILING CALENDAR, Peter Barlow, 1988, cover and June photo.

NEWSPAPERS:

PROVIDENCE JOURNAL;
- Jan. 16, 1973; photo, p. 1.
- Apr. 18, 1976; photo, p. B-1
- July 6, 1979; photo, p. W-1.
- Sept. 5, 1983; photo, p.1.
- Mar. 19, 1985; photo, p. X-3.

PROVIDENCE JOURNAL - SUNDAY MAGAZINE SECTION;

- Nov. 8, 1959; photo, p. 28.
- July 11, 1965; photo, p. 15.
- June 18, 1967; photo, p. 6.
- Mar. 10, 1968; photo, p. 17.
- June 17, 1984; photo, cover.
- Mar. 9, 1986; photo, cover.

SUMMERTIMES, Pawtuxet Valley Times, June 28, 1984; photo, p. 10.

YACHTING'S RACE WEEK NEWS, Welcome to Race Week; photo, p. 6.

Collected by Robert M. Downie,
Block Island, R.I.

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United States Bureau of Lighthouses. "Recommendation as to Aids to Navigation." July 9, 1913. Record Group 26, Box 840, file #1104A-1104E. National Archives, Washington, D.C.

United States Coast Guard. "Bill of Operations," Block Island Southeast Light Station. April 17, 1962. Boston Regional Branch, National Archives & Records Administration.

United States Coast Guard. "Request for Work Authorization." Project No. ecv-47-64. January 9, 1947. Boston Regional Branch, National Archives & Records Administration.

United States Coast Guard. File: ecv-626,220. February 10, 1950. Boston Regional Branch, National Archives & Records Administration.

United States Coast Guard. "Recommendation as to Aids to Navigation." January 5, 1939. Record Group 26, Box 840, file #1104B. National Archives, Washington, D.C.

United States Coast Guard. "Notice to Mariners." No. 18, February 13, 1948. Boston Regional Branch, National Archives & Records Administration.

United States Lighthouse Board. Correspondence. Record Group 26, Box 180, file #1102. National Archives, Washington, D.C.

United States Lighthouse Board. "Descriptive Lists of Light-Houses." Southeast Light site, 1873. Record Group 26, USCG Descriptive List Box. National Archives, Washington, D.C.

United States Lighthouse Board. "Letters to the Third Engineer." Record of Letters, No. 7 (Jan. 3, 1874-June 30, 1879). Record Group 26. National Archives, Washington, D.C.

United States Lighthouse Board. "Management of Lens Apparatus and Lamps." No date given. National Archives, Washington, D.C.

Weiss, George. <u>The Lighthouse Service: Its History, Activities and Organization</u>. Baltimore, Maryland: The Johns Hopkins Press, 1926.

Wheeler, Wayne. "America's First Lighthouse: Boston Light." <u>Keeper's Log</u> (Fall 1984): 2-5.

Notes

1. Pharos means lighthouse, so presumably the name was assigned to the island after the lighthouse had been built.

2. Francis Ross Holland, Jr., America's Lighthouses: Their Illustrated History Since 1716 (Brattleboro, Vermont: The Stephen Greene Press, 1972), 2.

3. The title of the world's oldest existing lighthouse goes to the lighthouse in Corunna, Spain. First mention of it occurs in the 4th century A.D., but it was most likely built earlier by the Romans. The square stone structure is approximately 130 feet tall. The tower went out of service at one time, but was later restored and encased in a light tower of granite by the Spanish government. It is still functioning as a lighthouse at the present time. Holland, 2.

4. Stevenson learned this from Practical Seamanship, an account published in 1777 by a Mr. Hutchinson, the dockmaster of Liverpool. Thomas Stevenson, Lighthouse Construction and Illumination (London & New York: E. & F.N. Spon, 1881), 54.

5. In Fresnel's own words, as read to the French Academy of Sciences in 1822: "There has existed for several years a Commission of Lights, the members of which were chosen from among the most distinguished scientists and the Inspectors of the Royal Corps of Engineers des Ponts et Chaussees. Charged with devising a general project for the distribution of light-houses upon the coasts of France, they sought at first to determine whether the system of illumination already in use could not be improved. Several interesting experiments had already been made upon the brilliancy of the light produced by small wicks placed in large Lenoir reflectors; but other duties, with which a majority of them were charged, prevented them from devoting the necessary time to these investigations. In 1819 M. Arago offered to take charge of these experiments, provided M. Mathieu and myself were allowed to assist him. This proposition, adopted by the Commission, was submitted to M. Becquey, Director General des Ponts et Chaussees, who also approved it, and desired me to devote the greatest care to these investigations. A wish [to be] worthy of his confidence, and of that of the Commission of Lights, as well as the importance of the subject, induced me to devote all my attention to these investigations." Augustin Fresnel, "Memoir upon a New System of Light-House Illumination," (1822) as it appeared in Leonce Reynaud,

Memoir Upon the Illumination and Beaconage of the Coasts of France (Washington, D.C.: Government Printing Office, 1876), 161.

6. T. Stevenson, (1881), 53.

7. Alan Stevenson, Account of the Skerryvore Lighthouse with Notes on the Illumination of Lighthouses (Edinburgh: Adam and Charles Black, 1848), 240.

8. Fresnel, 163.

9. Ibid.

10. Ibid., 165.

11. Ibid., 164.

12. A. Stevenson, 242.

13. Leonce Reynaud, Memoir Upon the Illumination and Beaconage of the Coasts of France (Washington, D.C.: Government Printing Office, 1876), 65.

14. Thomas Stevenson, Lighthouse Illumination, 2d ed. (Edinburgh: Adam and Charles Black, 1871), 10.

15. Fresnel, 169.

16. T. Stevenson, (1881), 55.

17. Holland, 23.

18. Fresnel, 171. "Evil intention" was also used in the United States, and some say it occurred on Block Island, although the majority of the histories indicate that the islanders were more concerned with saving lives and ships, rather than causing vessels to wreck on the rocks by falsely displaying harbor lights, etc.

19. George Weiss, The Lighthouse Service: Its History, Activities and Organization (Baltimore, Maryland: The Johns Hopkins Press, 1926), 35.

20. "Science for All" article, 358.

21. David P. Heap, Ancient and Modern Lighthouses (Boston: Ticknor & Company, 1889), 171.

22. Ibid., 172-173.

23. The information given in this section is provided so that, when speaking of the Southeast Light history, the reader will have a historical context within which to relate certain facts. More extensive information on the development of lighthouses and the Lighthouse Service can be found in Francis Ross Holland, Jr.'s America's Lighthouses: Their Illustrated History Since 1716 (Brattleboro, Vermont: The Stephen Greene Press, 1972).

24. It was Winslow Lewis, a ship captain, who in 1810 after years of testing convinced the Federal Government to adopt the Argand lamp and parabolic reflector system as a means of illuminating lighthouses. This was superior to the old spider lamp system previously used. However, its adoption was one of the factors which prevented the adoption of the infinitely better Fresnel lens. Holland, America's Lighthouses, p. 14-15.

25. Benjamin Silliman, Jr., and C.R. Goodrich, eds., The World of Science, Art, and Industry: Illustrated from Examples in the New York Exhibition, 1853-54, "The Fresnel Lens, or Dia-Catoptric Illuminating Apparatus for Light Houses" (New York: G.P. Putnam & Company, 1854), p. 145.

26. Heap, 205-206.

27. Ibid., 208. As described by George Weiss in 1926, the Lighthouse Service was still contracting out projects, although the plans and specifications were still prepared by the Service; "This is necessary because of the unusual engineering and architectural peculiarities involved in lighthouse construction." Weiss, p. 30.

28. Rev. S.T. Livermore, History of Block Island, Rhode Island, originally printed 1877 (Forge Village, Mass.: The Murray Printing Company, 1961 ed.), 9-19.

29. Nicholas Ball, Block Island, R.I.: Volume 3 - Lighthouses. Life Saving Stations. Cable. Typescript (Providence: Rhode Island Historical Society, 1890), 3.

30. The warranty deed was recorded on July 14, 1873, in the land records of the Town of New Shoreham, Block Island, Rhode Island, in Deed Book No. 15, pp. 17-18.

31. Michael Haltenberger, Ph.D., Physical Geography of Block Island, R.I.: Part I. (Budapest, Hungary: Hungarian Adriatic Association, 1917), 10-11.

32. United States Coast Guard, United States Lighthouse Board. "Descriptive List of Light-Houses," Southeast Light site, 1873, Record Group 26, USCG Descriptive List Box, National Archives, Washington, D.C.

33. The information of the last two contracts was obtained from the "Clippings File" of Record Group 26, Box 4, National Archives, Washington, D.C. This file contains all references to specific lighthouses as "clipped" from the Annual Report of the Lighthouse Board; the Southeast Light clippings were from 1872 to 1907. Also, when "lantern" is used in this report, it refers to the enclosed structure at the top of the lighthouse tower that contains the lens and lamp apparatus.

34. That is, from the records that could be found; many records of the Lighthouse Board and the later Bureau of Lighthouses were damaged by fire (at the National Archives in 1921) or misplaced and presumed lost in the absorption of the Lighthouse Service by the Coast Guard in 1939. Much of the pertinent information in this report has come from subject indexes, miscellaneous letters between the engineers, and correspondence of the Lighthouse Board, all found in Record Group 26 at the National Archives in Washington D.C.

35. "Letters to the Third Engineer," U.S. Lighthouse Board, Record of Letters, No. 7 (Jan. 3, 1874-June 30, 1879), Record Group 26, National Archives, Washington, D.C., p. 39. There is some discrepancy as to whether it was T.H. Tynan or J.H. Tynan.

36. Ibid.

37. "Specifications for a First Order Light-House (Brick Tower)," prepared at the office of the Light-House Board, October 1861 (Washington, D.C.: Government Printing Office, 1861) and "Specifications for a Double Dwelling for the Keepers of First Order Lights," prepared at the office of the Light-House Board (Washington, D.C.: Government Printing Office, 1862).

38. NPS Form 10-900, National Register of Historic Places Inventory - Nomination Form, "Block Island Southeast Light," form prepared by Richard Greenwood, Historical Consultant, 215 Indiana Avenue, Providence, RI, 02905, (401) 461-7193; for the Block Island Historical Society.

39. This information was obtained from various "Recommendations as to Aids to Navigation" and other correspondence of the Lighthouse Service (including estimates of cost, purchase orders, standard contracts), which can be found in the "Correspondence of the Bureau of Lighthouses, 1911-1939," Record Group 26, Box 840, files #1101-

1105A (Washington, D.C.: National Archives). I refer the reader to these writings for further information on other repairs such as plastering, pointing of stonework, repainting, etc., all too numerous and common to be mentioned here.

40. Reynaud, Memoir Upon the Illumination and Beaconage of the Coasts of France, p. 54. This had been suggested earlier by Alan Stevenson, who used a spherical mirror behind a Fresnel lens to collect and return the rays.

41. An isometric drawing of the original lens, compiled from photographs, the packing slip, and historical documentation, accompanies this report in the HAER measured drawings of the Southeast Light (1988).

42. "Management of Lens Apparatus and Lamps," U.S. Lighthouse Board, no date given, p. 11. According to this description, a hydraulic lamp is composed of a reservoir of the proper capacity to hold the oil needed for use in one night; a supply cistern, whose top is flush with the bottom of the reservoir; and a burner, whose crown is flush with the bottom of the cistern. A tube leads from the bottom of the reservoir into the cistern; at the end of this tube is a movable stop, which is in turn attached to a hollow metallic ball by means of a curved piece of metal. The ball regulates the flow of oil in the cistern by opening and closing the tube. The oil is then conducted from the cistern to the separate wicks by several tubes. There is an overflow cistern to catch any run-off. (pp. 10-11).

43. Fresnel in 1822 had an interesting suggestion for a "lamp alarm", in case the keeper was asleep when the lamp malfunctioned. He suggested placing a cup to catch some of the oil overflow, with the cup being balanced on a lever arm by a counterweight. The cup would be pierced by small hole that would empty it only if the overflow of oil stopped (which would indicate a malfunction). "But when the oil stops flowing, and before the light is extinguished, the cup empties, the counterpoise drops, and the motion of the lever disengages the spring of an alarm-bell. The noise of the bell continues for some time, and is sufficient to awaken the keeper." Augustin Fresnel, "Memoir Upon a New System of Light-House Illumination," (1822) as it appeared in Leonce Reynaud, Memoir Upon the Illumination and Beaconage of the Coasts of France (Washington, D.C.: Government Printing Office), 170.

44. Rev. Samuel T. Livermore, A History of Block Island From its Discovery in 1514 to the Present Time (Hartford, Conn.: The Case, Lockwood & Brainard Company, 1882 edition), 10.

45. Edward E. Pettee, Block Island Illustrated, with Descriptive Sketch, (Boston: Deland & Barta, 1884), 63-65.

46. The exact reasons for changing the light from fixed to flashing and from white to green are unknown, although it is possible to hypothesize as to the reasons. The other New England coastal lights that were similar in appearance, particularly Great West Light (and Point Judith, although a smaller fixed white), may have confused mariners. The choice of a green color may have been almost necessary, as many of the flashing lights in the immediate vicinity were already red and/or white. The choice of green for a primary light is somewhat unusual because, as mentioned in Part I, green is not as visible as red or white in bad weather situations.

47. J.A. Purves, "Modern Lighthouse Apparatus," Nature **61** (February 22, 1900): 393.

48. Ibid., 393.

49. No records or technical information were found which completely described the principles of the mercury float or which gave the gravity of mercury used in the device. It does not appear to actually float the entire weight of the rotatory lens assembly by sheer displacement. (A schematic diagram sent to us by the Coast Guard's Shore Maintenance Detachment appears to show some of the lens assembly's weight bearing on a ball thrust bearing in the lens spindle). Although numerous calculations were conducted by Richard K. Anderson, Jr., HAER Staff Architect, and myself, we were unable to determine the exact amount of mercury and the exact weight of the lens assembly from exterior measurements and the sparse written information on the interior measurements. Estimated weight of the mercury ranged from 600 to 2200 pounds; the weight range of the lenses was similarly as broad.

50. United States Bureau of Lighthouses, "Recommendation as to Aids to Navigation," April 29, 1931, Record Group 26, Box 840, file # 1104E, National Archives, Washington, D.C.

51. In a letter written by Mary Anna Clark, wife of head keeper Willet H. Clark in 1929, she reports the flash as being .3 seconds in duration and occurring every 3.7 seconds. The grammatical tense of the letter indicates that it was done either in 1929 or soon after, but by official account the light did not acquire this flash characteristic (which was still the characteristic in 1988) until 1933. Letter courtesy of Jean Napier (grand-daughter of Mary Clark), Block Island Historical Society.

52.United States Bureau of Lighthouses, "Recommendation as to Aids to Navigation," March 7, 1933, Record Group 26, Box 840, file #1104C, National Archives, Washington, D.C. Several handwritten notes on this form refer to a request made in May of 1931 that suggested the same idea, but had been ignored at that time. One note also comments that the 0.3 second flash is too short for an important light. There seems to have been some minor bickering going on.

53. Correspondence, Dept. of Commerce, Lighthouse Service, April 27-28, 1933, Record Group 26, Box 840, file #1104C, National Archives, Washington, D.C.

54. Commander, 1st Coast Guard District Project No. ecv-47-64, 9 January 1947, "Request for Work Authorization," Boston Regional Branch, National Archives & Records Administration.

55. Coast Guard Correspondence, 10 February, 1950, File: ecv-626, 220, Boston Regional Branch, National Archives & Records Administration.

56. This is a General Electric lamp bulb that is obtained by the Block Island Officer in Charge from North American Philips Lighting, distributed through Major Electric & Supply Inc., Pawtucket, RI.

57. Nicholas Ball, 14.

58. Pettee, 66.

59. "Correspondence of the Lighthouse Board," Record Group 26, Box 180, 1901-1910, file #1102, National Archives, Washington, D.C.

60. United States Bureau of Lighthouses, "Recommendation as to Aids to Navigation," July 9, 1913, Record Group 26, Box 840, file #1104A, National Archives, Washington, D.C.

61. United States Coast Guard, "Bill of Operations," Block Island Southeast Light Station, April 17, 1962, Boston Regional Branch, National Archives & Records Administration.

62. "Rhode Island in the War with Spain," compiled by the Executive Department of the State of Rhode Island and presented to the General Assembly, January session, 1900 (Providence: E.L. Freeman & Sons, Printers to the State, 1900): 346-348.

63. "Announcement: Block Island Wireless," Providence Journal, July 9, 1903 as contributed from the files of Robert Downie, Block Island, RI. Further information on the Block Island Wireless can

be found in Garrett D. Byrnes' and Charles H. Spilman's The Providence Journal: 150 years, (Providence, RI: The Providence Journal Company, 1980), 244-250.

64. United States Coast Guard, "Notice to Mariners, No. 18, 13 February 1948, Boston Regional Branch, National Archives & Records Administration.

65. Many Americans do not realize how close the enemies came to the New England coast during WW II. One of the most famous incidents occurred one day before the official end of the war, when the German submarine U-853 sank an American vessel in New England coastal waters. United States naval ships promptly sank the submarine 5 miles off the coast of Block Island as it tried to escape into deeper water.

66. United States Coast Guard, "Recommendation as to Aids to Navigation," Jan. 5, 1939, Record Group 26, Box 840, file #1104B, National Archives, Washington, D.C.

67. Much of the Lighthouse Service, and then the Coast Guard, correspondence is highly amusing but somewhat irrelevant to the report, so I have neglected to mention it in the text. It seems that the keepers had to ask permission for almost everything. One example is a request asking to move a yard playpen from one spot to another. Another amusing correspondence from 1909 involves the question, by a keeper, asking "whether a dog kept on a government reservation for light-house purposes, the property of the light-keeper, can be taxed by the local authorities," to which the Inspector of the Third Light-House District answered in June of 1909: "[Your letter] might be read to mean that the dog was kept for lighthouse purposes. The Board has no knowledge of authority ever having been granted for the employment of a dog, nor can the dog be considered light-house property as the Light-House Establishment in common with other governmental institutions is prevented by law from accepting presents." Record Group 26, Box 180, file #1102, National Archives, Washington, D.C.

68. The book by "Ben Mush" (probably an alias, as it appears on the title page in quotes) is entitled Block Island: A Hand-book with Map, for the guidance of summer visitors, telling how to reach that pleasant little place of resort, and what to do on getting there: together with description and sentiment calculated to adorn an otherwise plain tale, and to excite the interest of the apathetic, yet without too widely departing from the strict truth (Norwich, Conn.: James Hall, 1877), 30-33.

69. "Report on Southeast Light, Block Island, Rhode Island," File No. 5787, October 1985, as compiled by LeMessurier Associates, Inc., Cambridge, Mass.

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